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(54) **ELECTRONIC CIRCUIT COMPRISING ELECTRICAL CONNECTIONS RESISTANT TO A SEVERE ENVIRONMENT**

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USPC 335/278
See application file for complete search history.

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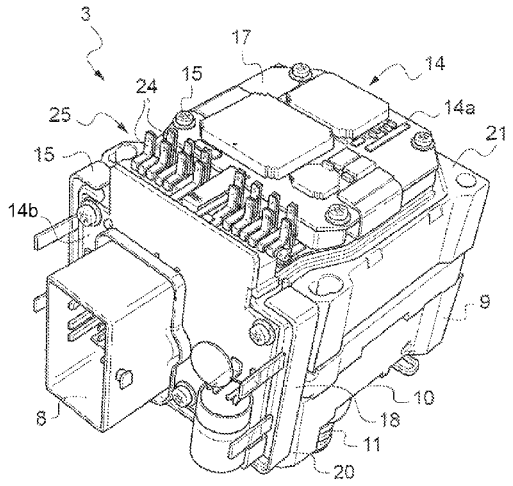
(57) **ABSTRACT**

The invention relates to an electromagnetic actuator comprising a housing (**9**) having several faces (**20**, **21**) and an electronic control circuit (**14**) split into at least two parts (**14***a*, **14***b*) distributed over at least two adjacent faces (**20**, **21**) of the housing (**9**), each part (**14***a*) of the circuit comprising at least one metallic connector (**25***a*) arranged so as to be connected electrically and mechanically with a metallic connector (**25***b*) of another part of the circuit (**14***b*) so as to form an electrical connection (**24**).

7 Claims, 4 Drawing Sheets



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H01R 12/57	(2011.01)
H01R 12/71	(2011.01)
H05K 1/14	(2006.01)

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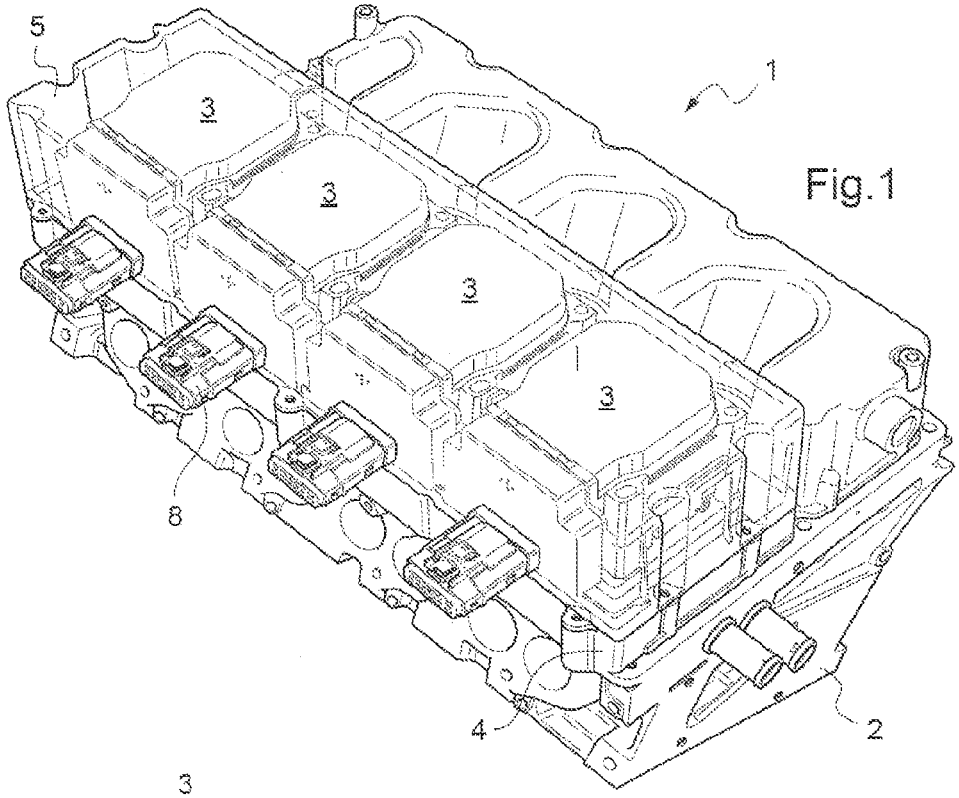

Fig.1

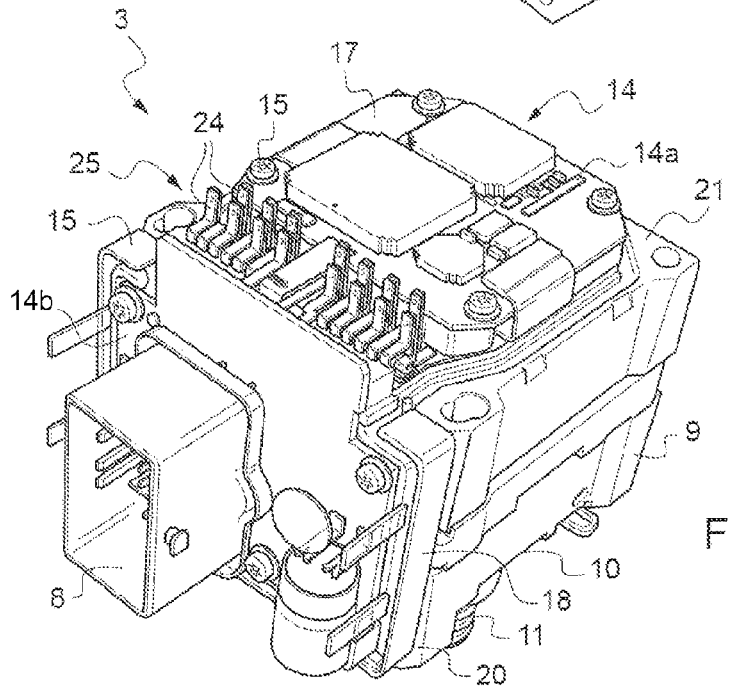

Fig.2

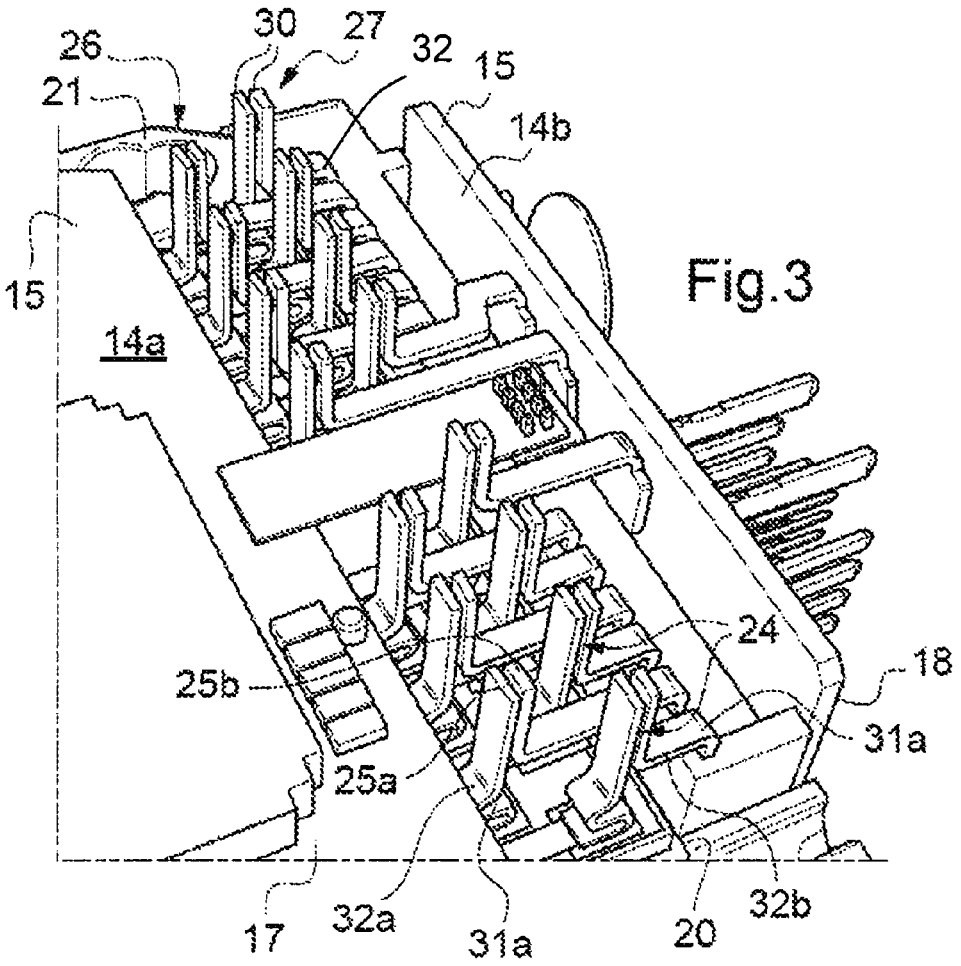

Fig.3

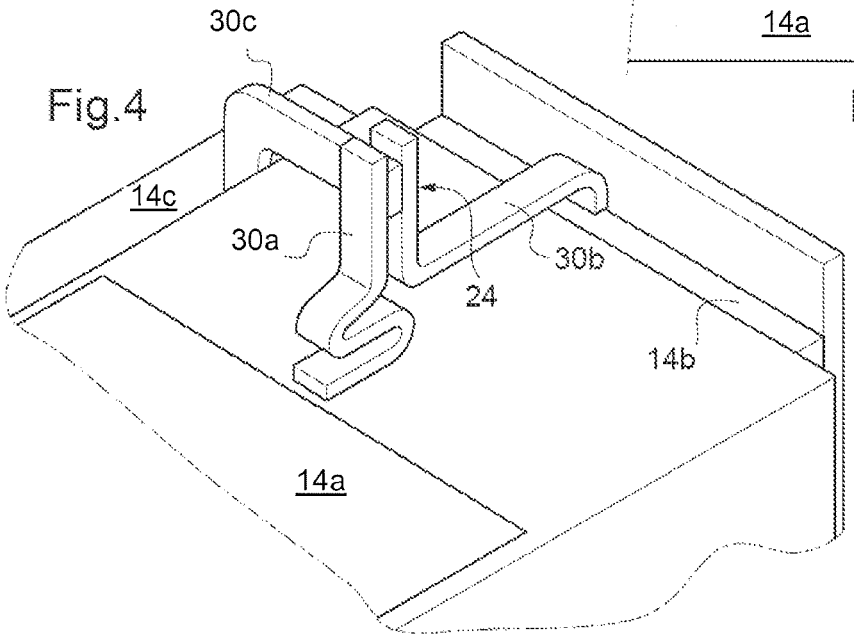
30c
14c
30a
24
30b
14b
14a

Fig.4

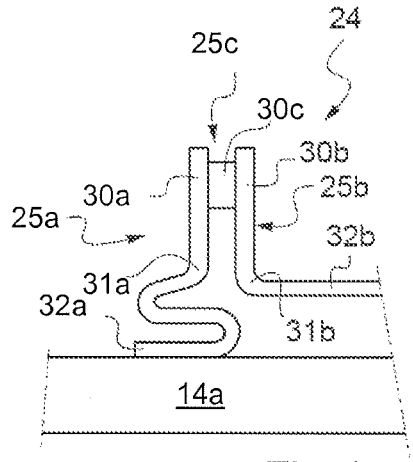
24
25c
30c
30b
25b
30a
25a
32b
31a
32a
31b
14a

Fig.4a

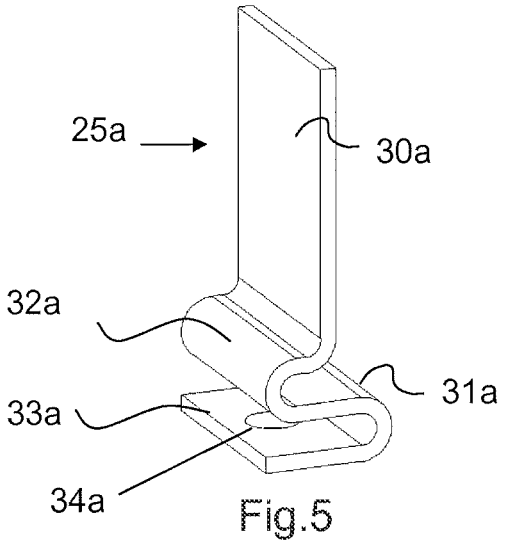

Fig.5

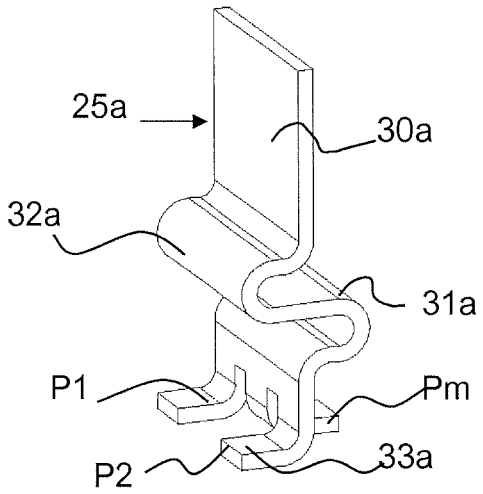

Fig.6

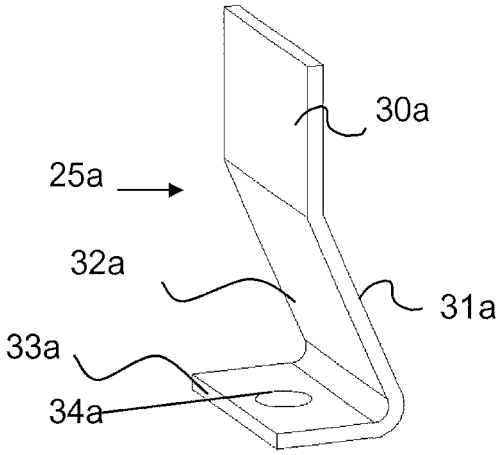

Fig.7

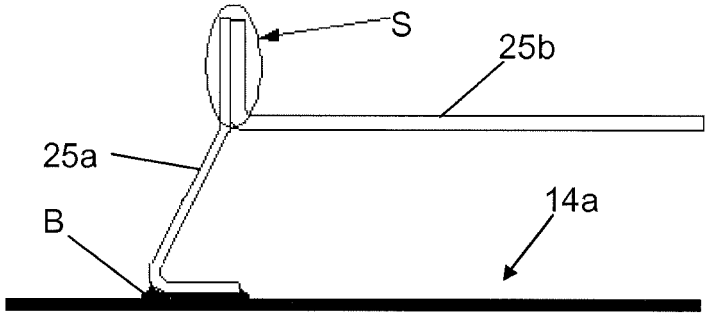

Fig.8

ELECTRONIC CIRCUIT COMPRISING ELECTRICAL CONNECTIONS RESISTANT TO A SEVERE ENVIRONMENT

The invention relates to the implementation of electrical connections between two electrical circuits or two portions of electrical circuit. In particular it applies to electromagnetic actuators.

BACKGROUND OF THE INVENTION

The most widespread motorization systems usually comprise an internal combustion heat engine comprising an engine block delimiting combustion chambers having one end closed by a cylinder head and an opposite end closed by a piston slidingly received in the engine block. The pistons are linked by a connecting rod to a crankshaft arranged to transform the reciprocating sliding movement of the pistons into a continuous rotary movement communicated to the drive wheels of the vehicle via the clutch and the gearbox. The cylinder head comprises ducts for connecting combustion chambers to an air-supply circuit and to an exhaust circuit for the burnt gases. In four-stroke heat engines, these connection means comprise valves that can move between a position of closing off the ducts and a position of opening the ducts.

In the motor vehicle field, the desire to reduce consumption and carbon dioxide emissions is leading manufacturers to incorporate electronic components within the engine in order to closely control each parameter thereof. The engine compartment of a vehicle is a severe environment in which a high temperature, vibrations and an atmosphere saturated with oil mist prevail. The electronic components and the electronic circuits in particular must be protected from the temperature and the oil in particular.

In order to optimize the efficiency of the engine, the purely mechanical members, such as the camshaft for actuating the valves, are frequently replaced by electromagnetic actuators controlled by an electronic circuit. These electronic circuits are installed as close as possible to the actuators in order to limit the cables between the control members and the actuators.

The actuators are driven by a control electronic circuit incorporating computing electronics and power electronics, sensors, interfaces, etc. Therefore, the circuits, which are produced on a flat rigid support, can be voluminous and occupy considerable space because of the integrated functions.

In order to limit the volume occupied by the electronic circuits, the support of the circuit could be attached to a face of the actuator housing. However, the dimension of the circuit would then be limited to the size of the actuator housing.

In order to restrict the volume occupied by the actuator, it is envisaged to divide the control circuit into several portions distributed over several faces of the actuator housing. The portions would then be linked together electrically.

Conventional connection means use an electrical connection comprising a male portion inserted into a female receiver, like a connection via pins. In connections with multiple pins, a portion of the circuit comprises a series of female sockets organized in a comb and the other portion of the circuit comprises a male grid receiving the female sockets. However, in the severe environment of the engine, this type of connection does not provide sufficient resistance to ensure the operation of the circuit over time, because the contact between the male and female portions of the connection involves pinching. Moreover, such a connection requires great precision in production because the sockets are usually small and do not withstand the deformations.

The invention therefore proposes a novel type of connection suitable for the environment of the engine.

SUBJECT OF THE INVENTION

The invention relates to a first electrical connector of an electronic circuit, said connector being in the form of a blade and comprising:

- a first portion forming a foot having a first sub-portion extending substantially on a plane and designed to be assembled by brazing onto said electronic circuit,
- a second portion extending in a direction substantially transverse to said brazing sub-portion of the first portion and comprising a contact surface designed to be placed in contact with an electrical connector.

According to one embodiment of the connector, the first portion comprises a flexible element between the brazing sub-portion and said second portion.

According to one embodiment of the connector, the flexible element comprises at least one fold.

According to one embodiment of the connector, the flexible element is substantially S-shaped.

According to one embodiment of the connector, the brazing sub-portion comprises at least two lugs extending on substantially the same line and separated by a median lug extending on the same line but in a direction opposite to the two lugs.

According to one embodiment, the connector comprises a thermally conducting material.

The invention also relates to a second electrical connector of an electronic circuit, said connector being in the form of a blade and having a portion comprising a surface designed to come into contact with the contact surface of the second portion of the first electrical connector.

The invention also relates to an electrical connection assembly of an electronic circuit comprising the first connector according to the invention and the second connector according to the invention.

The invention also relates to an electronic circuit comprising a support and at least the first connector according to the invention, said first sub-portion of the first portion of the connector being brazed onto the support.

The invention relates to an electronic circuit comprising at least two distinct portions, the portions of the circuit being electrically linked by connections comprising at least two connectors each linked to a portion of the circuit, each connector comprising a substantially flat contact surface and means for rigidly linking the contact surfaces together.

Therefore, the connections allowing the electrical link between the portions of the circuit are rigid and can withstand the high temperatures and the vibrations. The connection comprises no male or female portion which makes it possible to produce a strong mechanical link, for example by welding.

Advantageously, the connectors may comprise a flexible foot making it possible to adjust the respective positions of the connectors before assembly and providing flexibility in the connection so as to better withstand the vibrations and the expansion of the components.

According to one embodiment of the electronic circuit, the connector comprises a blade comprising at least one electrical contact surface and a foot extending the blade and linking the blade to a portion of the circuit.

According to one embodiment of the electronic circuit, the connectors are arranged so that the blade of a connector of a

first portion is placed parallel to at least one blade of a second portion so that the contact surfaces of each blade are in contact.

According to one embodiment of the electronic circuit, the connectors are connected by welding.

According to one embodiment of the electronic circuit, the connectors are connected by mechanical means.

According to one embodiment of the electronic circuit, the connectors comprise a flexible foot.

The invention also relates to an electromagnetic actuator comprising an electronic circuit according to the invention.

The invention also relates to an electromagnetic actuator comprising a housing having several faces and an electronic control circuit divided into at least two portions which are distributed over at least two adjacent faces of the housing. According to the invention, each portion of the circuit comprises at least one metal connector arranged to be electrically and mechanically connected to a metal connector of another portion of the circuit in order to form an electrical connection.

The electronic circuit may incorporate, amongst other things, computing electronics, power electronics, sensors or interfaces. The electronic circuit controls for example the operation and/or the power of the signal delivered to the actuator. In particular, the circuit is also called an electronic power circuit when it is incorporated into power electronics.

According to one embodiment of the actuator, the connections are placed so as to form teeth of at least two combs, the teeth of the combs being offset.

According to one embodiment of the actuator, each connector comprises a substantially flat electrical contact surface and means for rigidly linking the contact surfaces together.

According to one embodiment of the actuator, the connectors comprise a blade comprising at least the electrical contact surface and a foot extending the blade and linking the blade to a portion of the circuit.

According to one embodiment of the actuator, the connectors are arranged so that the blade of a connector of a first portion is placed parallel to at least one blade of a second portion so that the contact surfaces of each blade are in contact.

According to one embodiment of the actuator, a first circuit portion is made on a first support portion attached to an upper face of the housing, a second circuit portion is made on a second support portion attached to a front face of the housing, and the connectors of the first circuit portion comprise a blade oriented perpendicularly to the upper face of the housing while the blades of the connectors of the second circuit portion are oriented parallel to the front face of the housing.

According to one embodiment of the actuator, the connectors are connected by welding.

According to one embodiment of the actuator, the connectors are connected by mechanical means.

According to one embodiment of the actuator, the connectors comprise a flexible foot.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will be made to the appended drawings, amongst which:

FIG. **1** is a view of a motorization system according to the invention;

FIG. **2** illustrates an actuator, seen in FIG. **1**, without its capping according to the invention;

FIG. **3** is a detailed view of a first embodiment of the connectors of the electronic circuit of an actuator illustrated in FIG. **2**;

FIG. **4** is a detailed view of a second embodiment of the connectors of the electronic circuit of an actuator illustrated in FIG. **2**;

FIG. **4***a* is a detailed view of a connection seen in FIG. **4**;

FIG. **5** shows an example of an electrical connector according to the invention;

FIG. **6** shows another example of an electrical connector according to the invention;

FIG. **7** is yet another example of an electrical connector according to the invention;

FIG. **8** shows an example of an electronic circuit board according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The basic idea of the invention is to distribute the electronic circuit over the faces of the actuator housing in order to obtain a housing that is compact and incorporates a complete electronic circuit.

FIG. **1** illustrates a motorization system comprising a four-stroke internal combustion heat engine **1**. The engine **1** is formed of an engine block (not shown) and of a cylinder head **2** mounted on the engine block and covered with a cylinder head cover **5** delimiting with the cylinder head **2** a housing for a group of valve actuators **3**. The actuators **3** are attached to the cylinder head **2** and rest on the latter each by a shoe **4**. The cylinder head cover **5** is in this instance depicted as transparent in order to allow a glimpse of the actuators **3**. The general structure and the operation of such a heat engine are known in themselves and will not be explained in greater detail here.

The valve actuators **3** allow the actuation of the inlet and outlet valves instead of a camshaft. It is therefore possible to control each valve individually and to carry out complex and optimized combustion cycles. The actuators are produced as standalone members. They comprise members for the movement of the valves, usually an actuation sliding stem having one end interacting with the valve and one end secured to a vane accommodated in electromagnetic coils capable of exerting an attraction force on the vane in opposite directions. The coils are linked to an integrated electronic circuit controlling and powering the members for the movement of the valves.

FIG. **2** illustrates more particularly one of the actuators seen in FIG. **1**.

In this exemplary embodiment, the actuator comprises a metal housing **9** enclosing the members for the movement of the valves. Also shown, on a lower face **10** of the housing **9**, is a valve-actuation stem **11** and its return spring which protrude from the housing **9** and which are designed to be inserted into the cylinder head **2**. The actuator **3** also comprises a connector plug **8** placed on the front face and used to link the electronic circuit **14** to a power source and to an engine control unit or ECU.

More precisely, the electronic circuit bearing the reference **14** comprises a support **15** divided into a first support portion **17** and a second support portion **18**, and electronic components distributed over each support portion **17**, **18**. The support portions **17**, **18** are each attached respectively to a face of the housing **9**, in this instance to the upper face **21** and to the front face **20**. The electronic circuit **14** therefore comprises two portions **14***a* and **14***b* which are electrically linked together via electrical connections **24**.

The first circuit portion **14***a* is produced on a first support portion **17** which is attached to the upper face of the housing. A second circuit portion **14***b* is produced on a second support portion **18** attached to the front face **20**.

The circuit portions **14***a* and **14***b* are electrically linked by connections **24** arranged in two parallel combs **26** and **27** as illustrated in FIG. **3**.

The connections **24** are formed by the rigid mechanical assembly of a connector **25***a* and of a connector **25***b* which are electrically linked respectively to the circuit portions **14***a* and **14***b*.

Each connector **25** comprises a rigid blade **30** comprising a contact surface designed to be placed in contact with the contact surface of the blade **30** of another connector **25**. The blades **30** are supported by a foot **32** which electrically and mechanically links the blade **30** to the electronic circuit portion to which the connector belongs.

Since the housing **9** of the actuator is a parallelepiped, the connectors **25***a* of the circuit portion **14***a* comprise a blade **30***a* oriented perpendicularly to the upper face **21** of the housing while the blades **30***b* of the connectors **25***b* of the circuit portion **14***b* are oriented parallel to the front face **20** of the housing **9**.

The connectors are mounted on the support portions **17**, so that each connector **25***a* is placed facing a connector **25***b* when the circuit portions **14***a*, **14***b* are attached to the housing **9**. Thus, each blade **30** of each connector **25** is placed parallel to the blade **30** of the corresponding connector **25***b*, the contact surfaces facing one another.

The blades **30** of the connectors **25***a* and **25***b* are then assembled by welding to form the connection **24**.

The arrangement of the connections **24** in several parallel combs, of which the teeth are offset, makes it possible to space the connections **24** more, which makes the assembly of the connectors **25** easier. It is possible to align the connections **24** on a single comb, but the proximity of the connections **24** would lead to a more awkward welding operation.

The connections **24** thus produced perfectly withstand the temperature and the vibrations because they also produce mechanical links.

Advantageously, the connections **24** may comprise a flexible element in order to make it easier to place the blades **30** in contact with one another and to improve the resistance of the connection **24** to the expansion and the vibrations.

Thus, as illustrated in FIG. **3**, the respective feet **32***a* and **32***b* of the connectors **24***a* and **24***b* comprise respectively springs **31***a* and **31***b*.

The connector **24***a* comprises a foot **32***a* comprising a spring **31***a* formed of an S-shaped fold of the lower end of the blade **30**. The S-shaped spring is used to link the blade **30** to the circuit portion **14***a* over a short length while adding flexibility to the blade **30**, because the S shape of the spring is both compact and flexible.

Similarly, the connector **24***b* comprises a foot **32***b* comprising a spring **31***b* formed by a spring strip **35** perpendicular to the blade **30** and extending the latter. The strip also makes it possible to achieve the electrical link between the blade **30** and the circuit portion **14***b*.

Naturally, the invention is not limited to the embodiment described above.

Therefore, the choice of the type of spring depends essentially on the orientation of the connectors and on the distance separating the blades **30** from the circuit portions. The orientation of the connectors **25***b* advantageously makes it possible to use spring strips **31***b* which are easy to produce and make it possible to link the connectors **25***b* to the circuit portion **14***b*.

Similarly, the S-shaped springs **31***a* are adapted to the connector **25***a* because they are compact and make it possible to orient the latter perpendicularly to the circuit portion **14***a*.

The connectors **25** are preferably assembled by welding. However, any method making it possible to rigidly assemble the blades **30** can be envisaged, provided that the electrical link is established. Thus, it is possible to assemble the blades by screw and nut, or by another mechanical element of the clamp type.

It is important to note that the terms "first circuit portion and second circuit portion" have been chosen with no connection to a priority of one circuit portion over the other. Specifically, the position of the connectors, their respective orientations relative to the faces of the housing, their number and their respective arrangement are given only as an example.

It is also possible to divide the electronic circuit into more than two portions.

If the circuit comprises three distinct portions attached to adjacent faces, it is possible to use the same connectors to electrically link the portions together. Thus, the blades **30** of the connectors may be oriented perpendicularly to one another, provided that the contact surfaces of the blades **30** are parallel in order to be able to carry out the assembly. FIG. **4** illustrates an example of connection between three circuit portions **14***a*, **14***b* and **14***c* by virtue of the connectors **25***a*, **25***b* and **25***c*. The circuit portions are attached to perpendicular and adjacent faces of the housing **9** and the connection **25** is made in line with the face of the housing **9** comprising the circuit portion **14***c*.

FIG. **4***a* is a close-up of the profile connection **25** which shows the contacts between the three connectors.

The blades **30***b* and **30***a* are directed in parallel while the blade **30***c* is perpendicular to the other two while being held between the blades **30***a* and **30***b*.

The blades are assembled as described above and preferably by welding.

Therefore, it is possible to divide the electric circuit into as many portions as the housing has faces. The electrical links between the circuit portions can preferably be made as indicated above, but other types of connections are possible such as pins or flexible electrical wires welded between two points.

In order to simplify the manufacture and the installation of the electronic circuit, it is also possible to produce the support **15** of the circuit in a single piece. According to the exemplary embodiment illustrated in FIG. **2**, the support comprises a first portion **17** and a second portion **18**, which are independent, attached independently from one another to the housing **9**. But it is possible to produce a rigid support in a single piece, in the shape of an "L" or of an angle section, which would then be attached to the housing **9**. The electrical links between the circuit portions could therefore be made directly on the support according to a known method.

Thus, the circuit is divided into two portions distributed over two faces of the housing, but only one support **15** is necessary.

Advantageously, each support portion **17**, **18** incorporates connection means **25***a*, **25***b* connected together and to the circuit portions **14***a*, **14***b* in order to provide an electrical link of the circuit portions **14***a*, **14***b* with one another. Thus, the connectors **25***a*, **25***b* are supported by their respective supports.

The connectors **25***a*, **25***b* will be described more precisely by making reference to FIGS. **4** to **8**.

A first connector **25***a* has a blade shape and forms an electrical connection part of an electronic circuit **14***a*.

The first connector **25***a* comprises a first portion forming a foot **32***a* having a first sub-portion **33***a* extending substantially along a plane. This first sub-portion **33***a* is designed to be assembled by brazing onto the electronic circuit.

The first connector **25***a* also comprises a second portion **30***a* extending in a substantially transverse, or even perpendicular direction to the brazing sub-portion **33***a* of the first portion **32***a*. The second portion **30***a* comprises a contact surface designed to be placed in contact with an electrical connector.

In the connector **25***a*, the foot **32***a* separates the contact surface from the brazing sub-portion **33***a* in a direction that is transverse to the brazing sub-portion. Thus, when the connector **25***a* is mounted on the electronic circuit, a subsequent electrical connection of the electronic circuit may be obtained without requiring access to the surface of the circuit. Specifically, the first connector **25***a* shifts the contact surface above the electronic circuit. This avoids the environmental stresses of the electronic circuit which may prevent the access of the welding tools to the surface of the electronic circuit.

The brazing sub-portion **33***a* provides a mechanical and electrical contact between the first connector **25***a* and the electronic circuit. It is configured to provide a seat for the first connector **25***a* on the electronic circuit. For example, the brazing sub-portion **33***a* is in the form of a flat parallelepiped, as illustrated in FIG. **5**. In another example illustrated in FIG. **6**, the brazing sub-portion **33***a* comprises at least two lugs P**1**, P**2** extending on substantially the same line and separated by a median lug Pm extending on the same line but in a direction opposite to the two lugs P**1**, P**2**.

The brazing sub-portion may comprise a hole **34***a* making it possible to position the first connector **25***a* on the surface of the electronic circuit **14***a*. For example, the hole **34***a* is designed to receive a pin from the surface of the electronic circuit **14***a*.

By virtue of the brazing sub-portion **33***a*, the first connector **25***a* can be surface-mounted on the electronic circuit **14***a*, for example at the same time as other SMC components (Surface-Mounted Components). Once mounted on the circuit, the first connector **25***a* extends from a single face of the circuit.

The first portion of the first connector **25***a* may comprise a flexible element **31***a* between the brazing sub-portion **33***a* and the second portion **30***a*. The flexible element **31***a* makes it possible to absorb the mechanical clearances during the assembly of the first connector **25***a* on the circuit **14***a* or when placing the contact surface in contact with for example a second connector **25***b*. The flexible element **31***a* also makes it possible to compensate for the differential expansion of the connectors and of the electronic circuit during the temperature variations.

For example, the flexible element **31***a* comprises at least one fold. FIGS. **5** to **7** show examples of a first connector **25***a*. In FIGS. **5** and **6**, the flexible element is substantially S-shaped. In FIG. **7**, the flexibility is obtained by a single fold.

For example, the first electrical connector **25***a* comprises a thermally conductive material. Thus, the first connector **25***a* makes it possible to dissipate the heat generated by the electrical connection, for example by a second connector **25***b*. In particular, the first connector **25***a* allows heat transfer by means of the electronic circuit to a heat sink on which the circuit could be placed.

When the first connector **25***a* is mounted on the electronic circuit **14***a*, a second electrical connector **25***b* can then be placed in electrical contact, in particular rigidly linked with the contact surface of the first connector **25***a*. This produces the electrical connection of the electronic circuit **14***a* with, for example, another electronic circuit or a power source such as a battery.

The electrical connection of the electronic circuit **14***a* can then be produced at a distance from the surface of the electronic circuit. The electrical link point between the second connector **25***b* and the electronic circuit is shifted to a distance in a direction perpendicular to the electronic circuit **14***a*. The electrical connection of the electronic circuit **14***a* therefore avoids the difficulties of access to the surface of the circuit.

The second electrical connector **25***b* of the electronic circuit may be in the form of a blade and have a portion **30***b* comprising a surface designed to come into contact with the contact surface of the first connector **25***a*. In particular, the contact between the first connector **25***a* and the second connector **25***b* can be achieved by welding.

In the context of the present application, the electronic circuit is for example an electronic circuit board having a support and electronic components mounted on a surface of the support, also called a PCB (for Printed Circuit Board). For example, the first connector **25***a* is mounted on the electronic circuit board with other electronic components. The attachment of the first connector **25***a* and of the components may be achieved by brazing during a pass in an oven.

FIG. **8** shows an example of an electronic circuit board **14***a* which comprises at least the first connector **25***a*. The brazing surface **33***a* of the first connector **25***a* can be assembled to the support of the circuit board **14***a* by a braze B.

The second connector **25***b* can subsequently come into electrical contact with the first connector **25***a*. Preferably, the contact surfaces of the connectors **25***a*, **25***b* extend on a plane and are placed facing one another. The connection between the contact surfaces of the connectors **25***a*, **25***b* is therefore achieved on a plane. For example, the connection between the contact surfaces is achieved by a weld S. However, any method making it possible to rigidly assemble the contact surfaces can be envisaged, provided that the electrical link is established. Thus, it is possible to assemble the blades by screw and nut, or by another mechanical element of the clamp type.

The invention claimed is:

1. An electromagnetic actuator comprising:

a housing having several faces; and

an electronic circuit divided into at least two portions distributed over at least two adjacent faces of the housing, each portion of the circuit comprising at least one first metal connector arranged to be electrically and mechanically connected to a second metal connector of another portion of the circuit in order to form an electrical connection,

the first metal connector comprising:

a first portion forming a foot having a first sub-portion extending substantially on a plane and designed to be assembled by brazing onto said electronic circuit,

a second portion extending in a direction substantially transverse to said brazing sub-portion of the first portion and comprising a contact surface designed to be placed in contact with an electrical connector, and

the second metal connector comprising a portion having a surface designed to come into contact with the contact surface of the second portion of the first metal connector.

2. The electromagnetic actuator as claimed in claim **1**, wherein the first metal connector or the second metal connector is in the form of a blade.

3. The electromagnetic actuator as claimed in claim **1**, wherein the first portion comprises a flexible element between the brazing sub-portion and the second portion.

4. The electromagnetic actuator as claimed in claim **3**, wherein the flexible element comprises at least one fold.

5. The electromagnetic actuator as claimed in claim **3**, wherein the flexible element is substantially S-shaped.

6. The electromagnetic actuator as claimed in claim 1, wherein the connector comprises a thermally conducting material.

7. The electromagnetic actuator as claimed in claim 1, wherein

the electronic circuit comprises a support, and

the first sub-portion is brazed onto the support.

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